REPORT No. 137

POINT DRAG AND TOTAL DRAG OF NAVY STRUTS No. 1 MODIFIED

By A. F. ZAHM, R. H. SMITH, and G. C. HILL
Bureau of Construction and Repair
Navy Department

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INTRODUCTION.

This report presents the results of tests on struts conducted at the Washington Navy Yard for the Bureau of Construction and Repair of the Navy Department. Two models of the modified Navy strut, No. 1, were tested in the 8 by 8 foot wind tunnel. The tests were

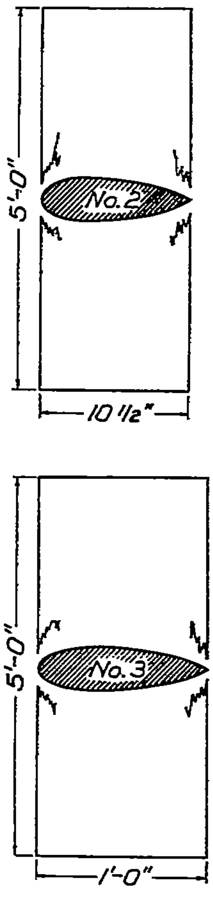


Fig. 1.—Navy struts Nos. 2 and 3.

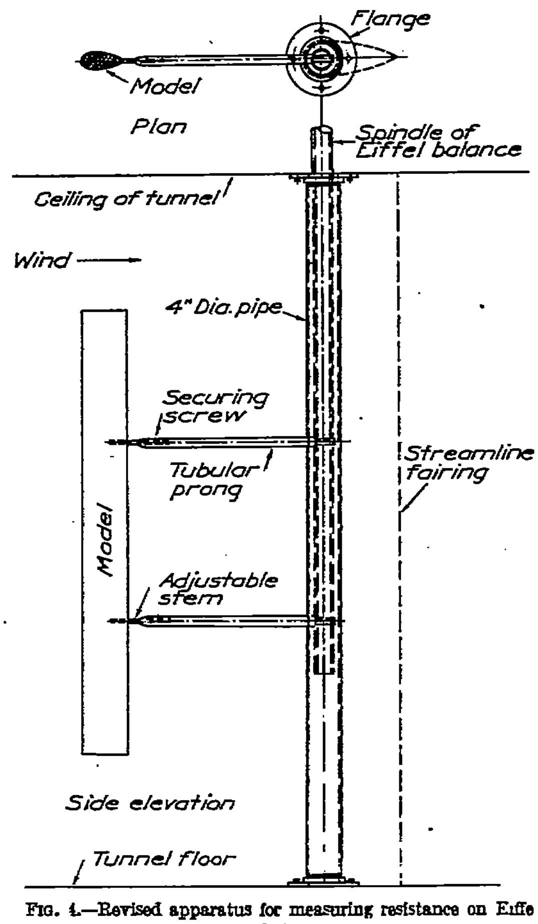


Fig. 4.—Revised apparatus for measuring resistance on Eiffel balance.

made to determine the total resistance, end effect, and the pressure distribution at various wind tunnel speeds with the length of the strut transverse to the current. Only the measurements made at zero pitch and yaw are given in this report submitted to the National Advisory Committee for Aeronautics for publication.

DESCRIPTION OF MODELS.

The two struts were normally 5 feet long by 3 inches thick and of the cross-sectional shape shown in figure 1, the larger strut being 12 inches wide and called No. 1a, the smaller 10.5 inches and called No. 1b. The offsets are given in Table I, and are derived from the original

Navy 1 strut 3 inches thick by uniformly stretching it along stream so as to change the original abscissas to the present ones. Both struts were made of pine wood, varnished, and satisfactorily verified by application of their steel templates; both were hollow for the admission of a central steel shaft; both had detachable end segments to fill up all or a portion of the space between their ends and the floor and ceiling.

As shown in figure 2, the central steel shaft rested in a conical socket on the floor of the tunnel and extended vertically through the strut and its dummy end pieces, thence up through the ceiling of the tunnel. By altering the lengths of the segmental dummy struts at the top and bottom, any length of gap at either strut end could be provided, ranging from one-thirty-second of an inch to 18 inches, and by rotating the strut system about the shaft any desired angle of incidence could be maintained during the measurements of pressure distribution over a median section.

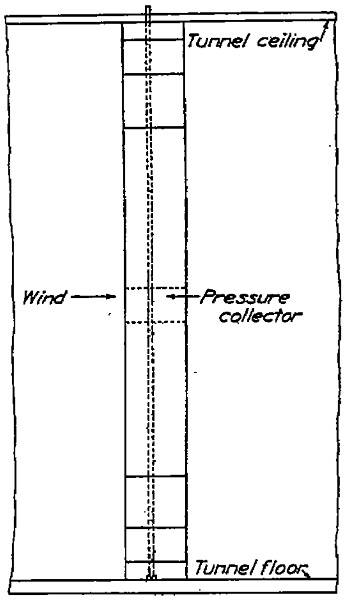


FIG. 2.—Arrangement for varying gap and angle of yaw for Navy strut No. 2.

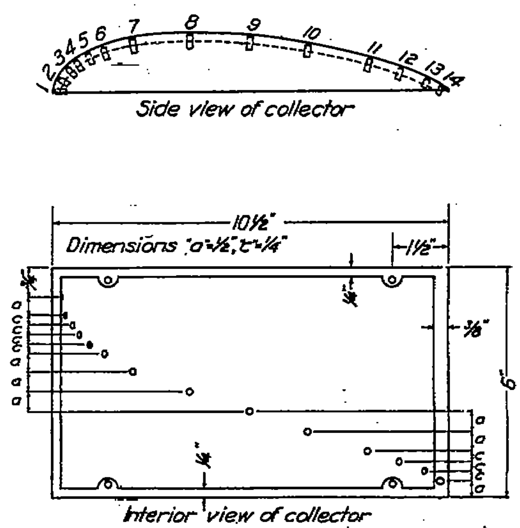


FIG. 3.—Bronze pressure collector for Navy strut No. 2.

The point pressure on the larger strut was not measured. For the smaller of the two struts the arrangement of the 14 pressure collectors, to which 14 tubes from a multiple-tube manometer were attached, is shown in figure 3. An arched bronze side plate, flush with the strut at its middle, has 14 fine holes on its outer surface and as many nipples inside serving as pressure leads, from which rubber tubes run up through the hollow strut to the manometer.

METHOD OF MEASURING PRESSURE DISTRIBUTION.

The pressures at these 14 holes, referred to that in the undisturbed stream well to one side of the strut, were measured at 20, 30, 40, 50, and 60 miles an hour. They were simultaneously indicated on the inclined multiple-tube manometer, whose reservoir was joined to the static lead of the reference speed nozzle in the undisturbed air stream. The pressure could be read accurately to ½ per cent at speeds above 40 miles an hour. For the lower speeds of the test it could be read thus accurately at all the holes where it equaled or exceeded 40 per cent of the nose pressure, as given in Table III. The usual pressure drop correction was made by multiplying the volume of the strut by the static pressure gradient along the tunnel.

The angle of yaw was set accurately to about one-fiftieth of a degree by means of a template whose extremities served as a reference line. Slight lateral and angular displacements of the strut were prevented by fine stay wires anchoring its leading and trailing edges to the walls of the tunnel. The end dummies were kept accutatély in line and orientation with the strut.

The speed of the air was held constant to within one-half of 1 per cent. It was measured with a standard pitot static tube placed about 18 inches to one side of the strut center and nearly the same distance above and before it.

METHOD OF MEASURING TOTAL RESISTANCE OF THE STRUTS.

The total resistance of the struts was measured at zero pitch and yaw and at speeds of 20, 30, 40, 50, 60, and 70 miles an hour and with various end gaps from one-thirty-second of an inch to 18 inches. The manner of doing this is illustrated in figure 4. Two heavy prongs extending upstream from the shielded shank of the Eiffel balance supported the strut in an upright position and held it securely without causing material air disturbance, while allowing it to swing freely along stream with the small oscillations of the balance. Moment measure-

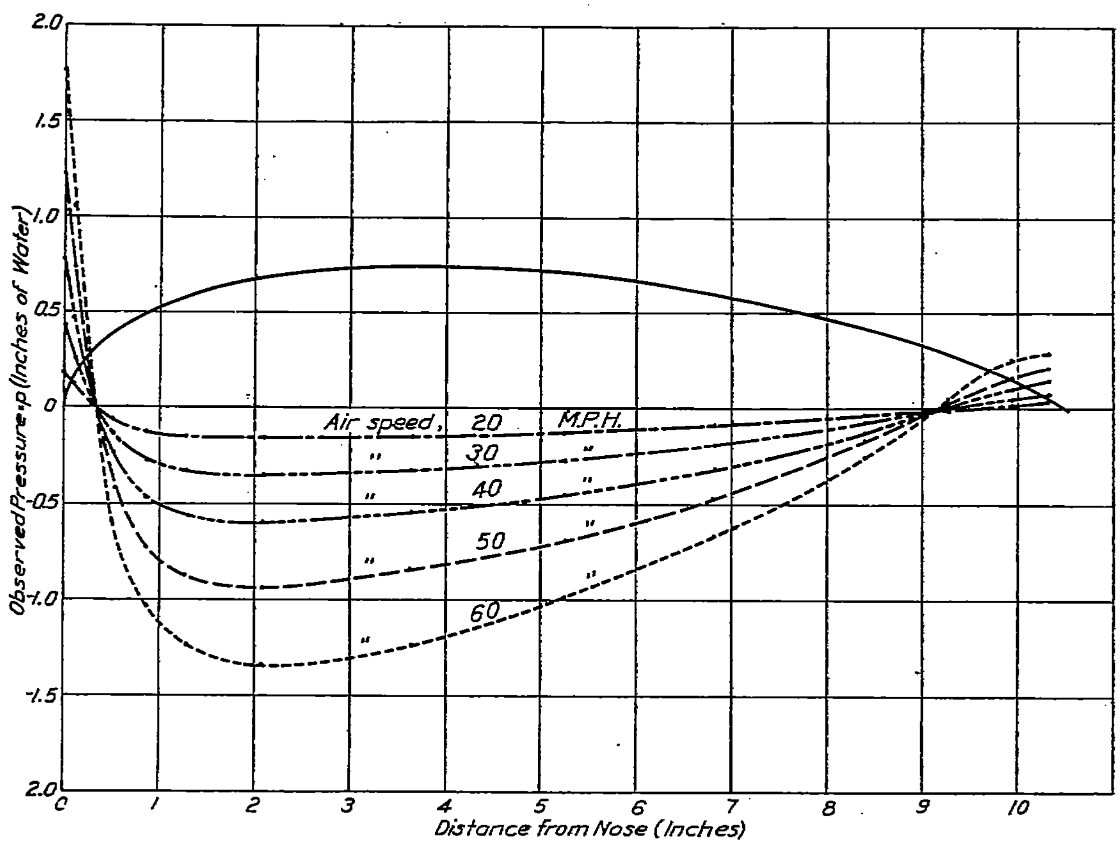


FIG. 5.—Observed pressure vs. aft distance of holes at zero pitch and yaw for Navy strut No. 2.

ments about one knife-edge were made, first of the strut and prongs, then of the prongs alone with the strut detached but not removed. The difference was taken as the net moment of the strut, which divided by the arm gave the strut drag, except for the pressure drop correction already mentioned.

RESULTS OF PRESSURE MEASUREMENT.

Figure 5, plotted from Table II, delineates the pressure distribution at the 14 holes for zero pitch and yaw and for the five wind speeds used. For each speed there is a point of full impact pressure $\frac{1}{2}\rho V^2$ at the nose, and two points of zero pressure at the side, the first at a distance of 3.3 per cent of the strut width from the front, the second at a distance of 87.1 per cent. At about one-fifth of the width from the leading edge occurs the maximum suction, which equals about three-fourths of the nose pressure. At the last hole the pressure is about one-sixth of the nose pressure. These various characteristic points shift little if any with the speeds used. This fact may be contrasted with those given in Report No. 191 of the British Advisory Committee for Aeronautics, describing the sudden change in the character of the air flow about a 6-inch sphere and a 6-inch cylinder at 25 to 30 miles an hour. Figure 5 shows that at all the holes and at all the speeds used p is an increasing function of V.

As indicated by the diagrams in figure 6, plotted from Table III, for zero pitch and yaw, the pressure at each hole varies nearly as the square of the velocity, but with a degree of approximation slightly diminishing aft of the thickest part of the strut and more pronouncedly at the lower speeds. The amount and direction of departure from the V^2 law is clearly disclosed in figure 6 and Table III.

The graphs of the faired values of the point-pressure p at 60 miles an hour, and at other speeds multiplied by $(60/V)^2$ to make the pressures comparable, are shown in figure 7. The integrals of the segments of each pressure graph, giving the elements of the pressural drag and the summation of these called the "form resistance" or "resultant pressural drag," are given in Table IV and plotted in figure 16. With them are shown the total directly measured drag and the resultant friction, the latter being the difference between the whole drag and the whole pressural drag. The order of graphic integration here used to find the force $\int pdy$, over the various portions of the surface of the 1-foot-long center segment of the strut, is detailed at the bottom of Table IV.

The lower half of Table IV is of especial interest as showing the relation of the whole drag to its parts. For this particular model the drag at 40 miles an hour is about one-fourth friction and three-fourths pressure. The total upstream pressure is 5.8 times the whole resultant drag, 7.7 times the resultant pressure, and 24 times the resultant friction; and the downstream pressure is about 13 per cent greater than the upstream pressure. With such thick streamline shapes, therefore, an error of 1 per cent in measuring the point pressure may entail errors of the order of 8 per cent in the derived pressural drag, 25 per cent in the frictional. No such difficulty is found in measuring the resistance of normal planes or thin planes placed edgewise in the current, where the force is all pressure or all friction.

The total drag and its elements, as seen in Fig. 16, vary as V^n for the range of speeds used. The velocity exponent n equals 1.99 for both the push and the suction before the major section. Aft of this section n=1.895 for the suction, 1.985 for the push. For the total measured drag n=1.88; for the total pressural drag 1.71; for their difference, which is called the frictional drag, n=2.35, which is doubtless too great.

Since the resultant pressural drag and frictional drag are derived by taking the difference between much larger quantities, it is not believed that the values so determined from the present measurements are trustworthy. The friction on a plane equal to the side elevation of the strut segment, computed directly by well-known formulas, would be materially greater than the friction here found, and would vary approximately as the power n=1.85, and if subtracted from the total measured resistance would leave a smaller pressural resistance varying according to a greater value of n. No exact formula is available for computing the actual surface friction on the strut segment, even though the velocity at each point were known. The other values plotted in Fig. 16 are much more trustworthy, and indicate the comparative effectiveness of the various elements of the strut surface.

It has just been said that the downstream pressure exceeds the upstream by 13 per cent. In a frictionless fluid they would be equal. In N. P. L. Report 600 Jones and Williams, from their point-pressure measurements on an ellipsoid, declare "they show that the form resistance may be zero or even negative, or that the accuracy of the experiments is not sufficient to enable it to be found." A careful Italian reports the air pressure on a torpedo form greater upstream than down. A painstaking American physicist recently tested a projectile which showed a negative drag in a high-speed air stream. If such things can be, one may look for an airship hull competent to pull itself around the world without engine power.

The present data will aid in the study, soon to be made, of the lift and drag effects of surface finish and obstructions. It were better if such data could be checked by theory. But for lack of time the stream function was not determined for the present strut. The pressure over its forward part is theoretically approximated in the following paragraph.

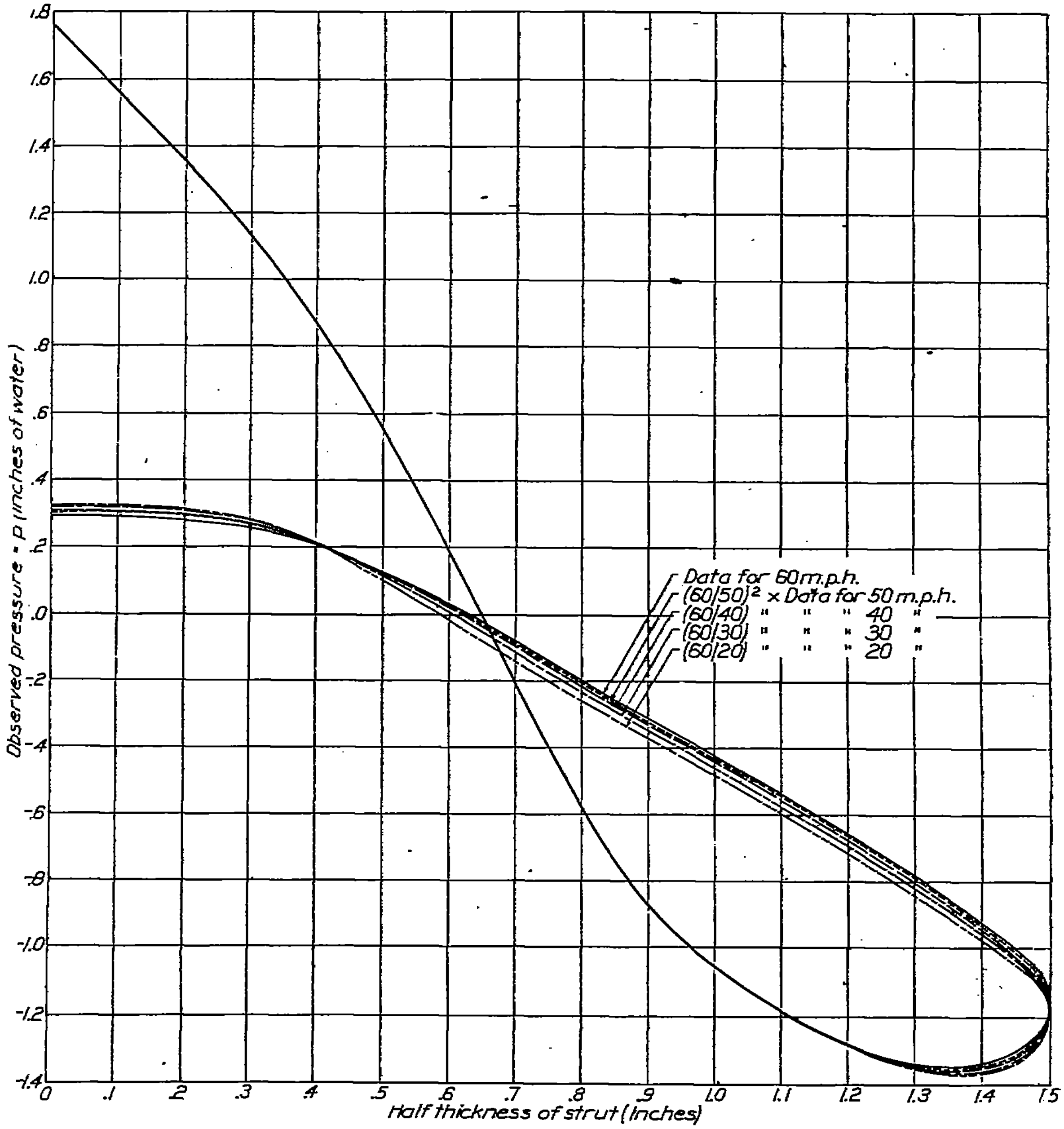


FIG. 7.—Observed pressure vs. half thickness of strut at various air speeds for Navy strut No. 2 at zero pitch and yaw.

PRESSURE ON AN ELLIPTIC CYLINDER IN A PERFECT FLUID.

The point pressure on the front half of a long elliptic cylinder having the shape and size of the fore part of the smaller model was calculated for zero pitch and yaw in a frictionless atmosphere of standard density flowing uniformly past it at 40 miles an hour. To do this the stream velocity along the elliptic section was found by the usual hydrodynamic process (Lamb, article 71) and substituted in Bernouilli's equation to find the point pressure along the section. The values so computed are given in figure 8. The agreement between the calculated and observed values is close for the foremost holes, but more or less divergent for the holes farther aft in the part of the surface before the major section. This discrepancy was caused, no doubt, by the shape of the after part of the strut as well as by the viscosity of the medium. The general agreement, as shown in figure 8, may be compared with a like diagram for the pressure distribu-

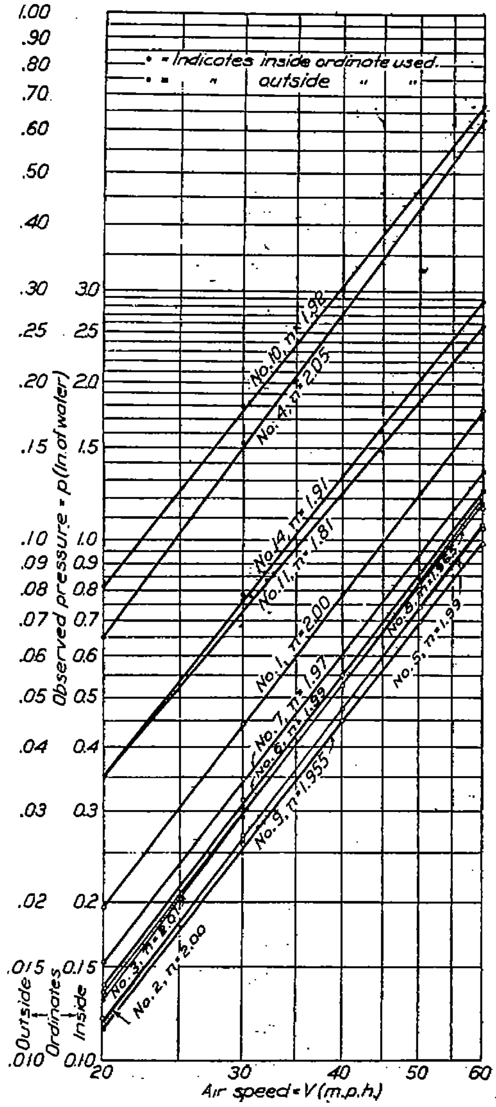


FIG. 6.—Observed pressure vs. velocity at zero pitch and yaw for Navy strut No. 2.

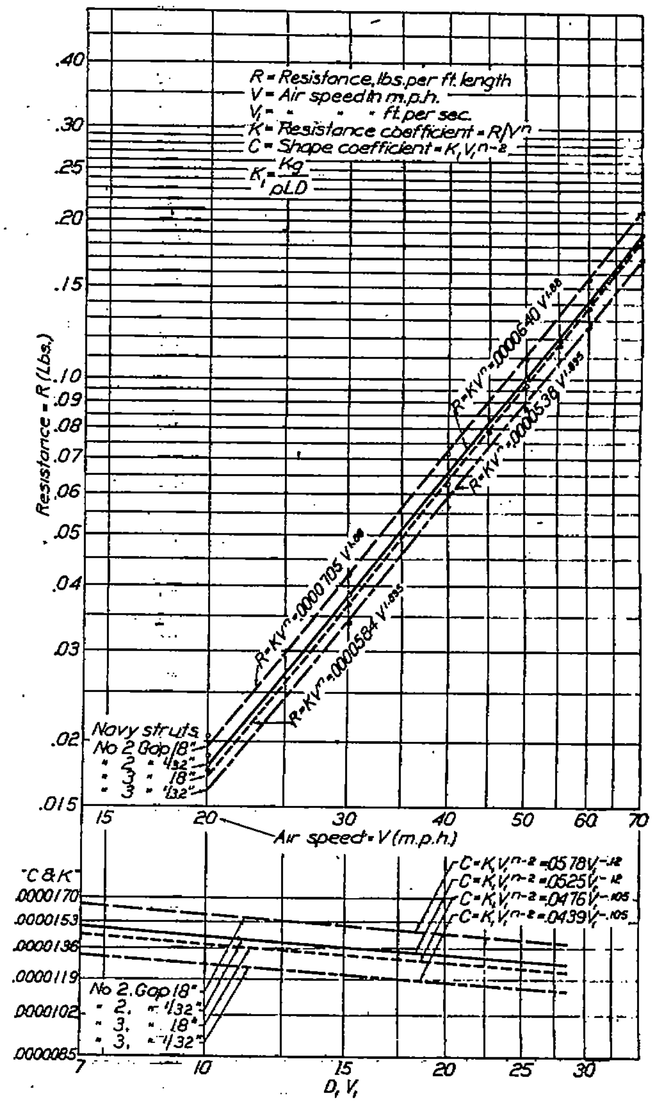


FIG. 9.—Resistance and shape coefficients for Navy struts Nos. 2 and 3.

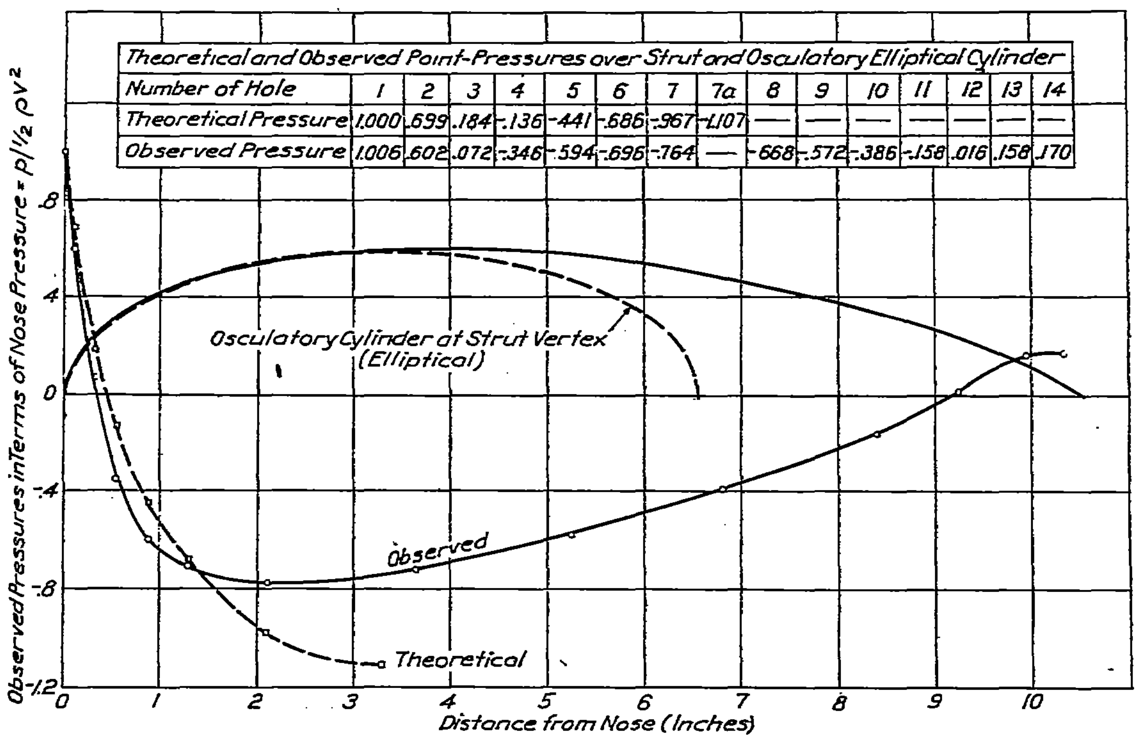
tion over the spheroidal bow of a torpedo form, given in Report No. 600 of the British Advisory Committee for Aeronautics for April, 1919.

RESULTS OF TOTAL RESISTANCE MEASUREMENT.

Tables V and VI give the measured and net resistance and derived coefficients for the two struts at various wind speeds and at zero pitch and yaw, for gaps of $\frac{1}{32}$ inch and 18 inches. Figure 9 plotted on logarithmic paper from these tables gives the net resistance versus speed;

also the shape coefficient C and engineering coefficient K plotted against speed times thickness from faired values taken from the straight-line resistance graphs. At the test speeds above 30 miles an hour the resistance graphs are properly straight lines; for the lower speeds the resistance values in each case plot considerably above the straight line. These diagrams may be compared with similar ones given in earlier Navy aerodynamic reports on streamline forms, especially airship hulls, in which the data commonly lie all on a straight line.

The values of C and K, taken directly from Tables V and VI, are plotted on plain section paper in Figures 10 to 13 for convenience of comparison with previous strut reports. On



Theoretical and Observed Point-Pressures over Strut and Osculatory Elliptical Cylinder															
Number of Hole	1	2	3	4	5	6	7	7a	8	9	10	11	12	13	14
Theoretical Pressure	1.000	.699	.184	-.136	-.441	-.686	-.967	-1.107	—	—	—	—	—	—	—
Observed Pressure	1.006	.602	.072	-.346	-.594	-.696	-.764	—	-.668	-.572	-.386	-.158	.016	.158	.170

FIG. 8.—Pressure distribution at zero pitch and yaw, air speed 40 m. p. h. for Navy strut No. 2.

transferring the shape-coefficient graphs for an 18-inch gap to the similar graph for four Navy No. 1 struts, it appears that the present coefficients fall above the others at high speeds and below them at low speeds and show that the original Navy No. 1 struts are better for practical flying speeds.

Table No. VII gives the effect of gap on the shape coefficient for the two struts at various speeds and at zero incidence in pitch and yaw. Figures 14 and 15 exhibit these results graphically. From these diagrams it appears that the effect of enlarging any gap beyond one strut thickness is practically negligible. The running resistance of both struts is then 8 to 12 per cent greater than with zero gap, or for a strut infinitely long. Reference may here be made to N. P. L. Report T843 showing an increase of 8 per cent in resistance as the strut gap increases from zero to a large amount for two struts, also 5 feet long, exposed like the present ones, but to a wind speed of 45 feet per second, the one measuring 3 by 7½ inches in cross section, the other measuring 3 by 15 inches.

DRAG VERSUS STRUT LENGTH.

It may be assumed that the increment of drag due to end turbulence for these 5-foot struts has the same absolute value as if they were somewhat shorter, or were indefinitely longer and placed in a like stream large enough to obviate wall blanketing. If this assumption be true, the resistance plotted against strut length is a straight line of the form $R = Kl + E$, where l is the variable strut length and E the constant increment of drag due to end turbulence. Also it may

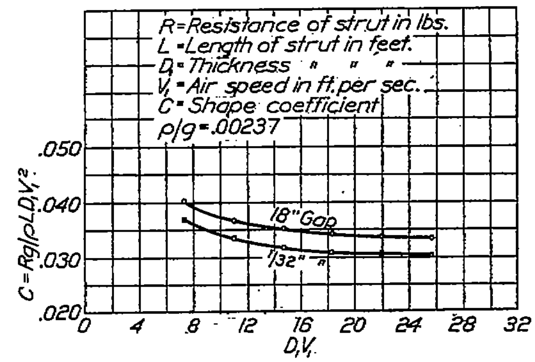


FIG. 10.—Shape coefficient in terms of thickness and speed for 3" x 10½" Navy strut No. 2 at zero pitch and yaw.

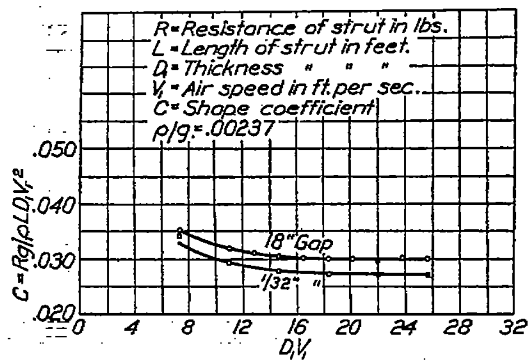


FIG. 11.—Shape coefficient in terms of thickness and speed for 3" x 10½", Navy strut No. 3 at zero pitch and yaw.

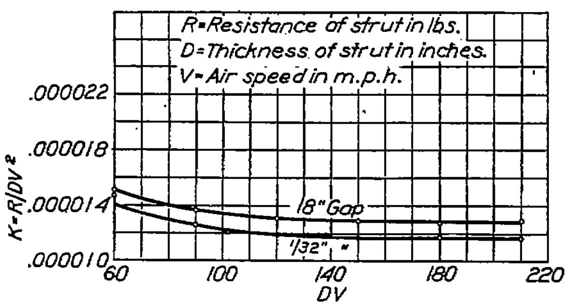


FIG. 12.—"K" in terms of thickness and speed for 10½" x 3", Navy strut No. 2 at zero pitch and yaw.

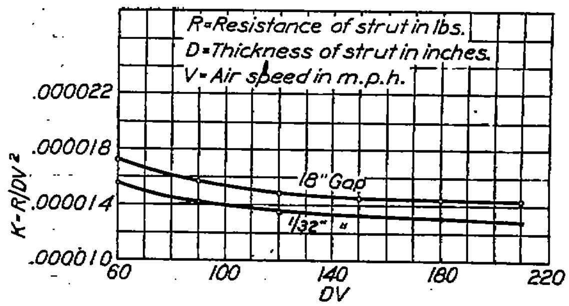


FIG. 13.—"K" in terms of thickness and speed for 12" x 3", Navy strut No. 3 at zero pitch and yaw.

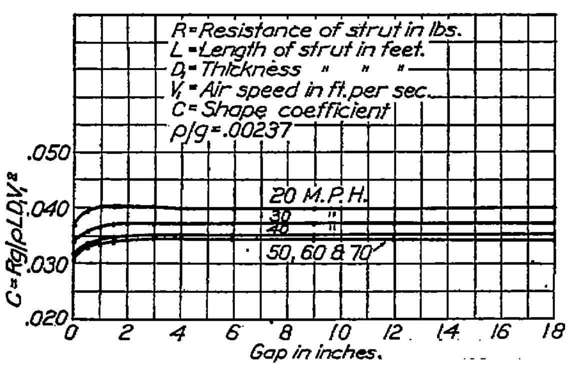


FIG. 14.—Shape coefficient in terms of gap for 10½" x 3", Navy strut No. 2 at zero pitch and yaw.

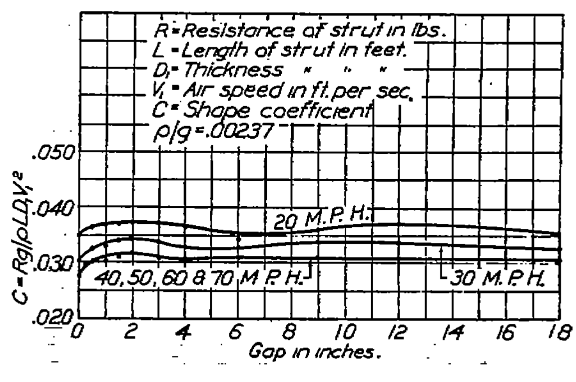


FIG. 15.—Shape coefficient in terms of gap for 12" x 3", Navy strut No. 3 at zero pitch and yaw.

be assumed that in these various cases the pressure distribution at the strut middle would be substantially the same at the same wind speed. But no experiment was made to test these assumptions.

DISK RATIO.

At 40 miles an hour, and including end effect, the ratio of drag of the major section of the strut to the actual drag on the strut itself is 21.87 for the smaller model, 24.93 for the larger. The drag of the major section was taken as the resistance, actually measured, of a thin rectangular plate 3 by 60 inches held normal to the wind at 40 miles an hour.

For the 3 by 60 inch Navy 1 strut the disk ratio at 40 miles an hour is 23.7. For the "best form of strut as regards resistance" given in N. P. L. Report R. and M. No. 416, the disk ratio for a 3 by 60 inch model at 40 miles an hour is 18.15, as estimated from Plate II of that report.

The present high values of the disk ratio, based on strut resistance measurements made with the old Eiffel balance, have not yet been checked against measurements made with the new balance. But the Eiffel balance was usually found reliable for measuring the resistance of a strut held vertical on two prongs pointing upstream, as shown in figure 4.

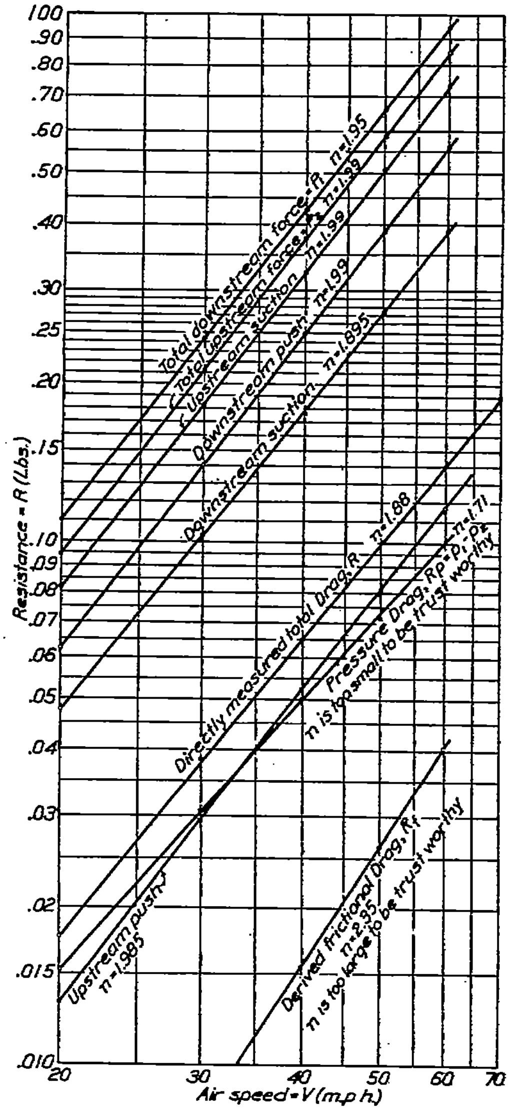


FIG. 16.—Total drag and its elements for Navy struts Nos. 2 and 3.

NOTE.

On going to press it is discovered that a too-high gradient was used in computing the pressure-drop correction, thus entailing an error of about 4 per cent in the values here given of the total drag at all speeds.

CONCLUSIONS.

The total resistance and end effect found for the two struts herein described showed no new features beyond those disclosed by well-known tests.

The point pressure along the contour of the middle cross section of the 3 by 10.5 inch strut, when integrated to give the pressural drag, showed this to be about three-fourths of the total drag at 40 miles an hour, the remaining one-fourth being frictional drag along the section. The resultant pressure (downstream) was 11.5 per cent of the integrated downstream pressure, 13 per cent of the integrated upstream pressure.

All along the section the pressure (p) increased continuously with the air speed V; closely as V^2 before the thickest part of the strut, and less nearly at V^2 farther aft.

As usual the nose pressure is $\frac{1}{2}\rho V^2$; also at all speeds one point of zero pressure occurs at 3.3 per cent of the strut width aft of the nose, another at 87.1 per cent aft.

The total drag of the 5-foot strut neglecting end effect varied about as $V^{1.9}$ and was 8 to 12 per cent less than for a free-ended strut 5 feet long. The whole drag, including end effect, was about one twenty-second that of a normal plate having the same front elevation.

From the limited premises of this text it may not be well to draw very general conclusions. One might expect however that the chief observations would be fairly repeated on other well-shaped struts not too different from those here described.

Doubtless for all thick shapes of slight resistance the resultant pressure is small compared with the integrated upstream or downstream pressure. Hence the pressural drag can not be very accurately determined from point-pressure measurements of ordinary accuracy nor the friction by taking the pressural drag from the total drag as is sometimes done.

It is believed that the present method of analyzing the pressure elements may be usefully employed to understand or improve the character of the drag on stream-line models generally.

The drag of this strut is less at low speeds, greater at high speeds, than that of the original Navy No. 1 strut of the same size, which latter is one of the best on record.

TABLE I.—*Specified offsets for Navy struts No. 2 and No. 3.*

Navy strut No. 2.		Navy strut No. 3.	
Distance from nose (inches).	Thickness of strut (inches).	Distance from nose (inches).	Thickness of strut (inches).
0	0	0	0
.262	1.110	.300	1.100
.525	1.584	.600	1.584
.787	1.905	.900	1.905
1.050	2.160	1.200	2.160
1.312	2.361	1.500	2.361
1.575	2.520	1.800	2.520
1.837	2.640	2.100	2.640
2.100	2.751	2.400	2.751
2.625	2.880	3.000	2.880
3.150	2.961	3.600	2.961
3.675	3.000	4.200	3.000
4.200	3.000	4.800	3.000
4.725	2.997	5.400	2.997
5.250	2.880	6.000	2.880
5,775	2.757	6.600	2.757
6.300	2.580	7.200	2.580
6.825	2.415	7.800	2.415
7.350	2.214	8.400	2.214
7.875	1.965	9.000	1.965
8.400	1.704	9.600	1.704
8.925	1.395	10.200	1.395
9.450	1.020	10.800	1.020
9.975	.585	11.400	.585
10.500	0	12.000	0

TABLE II.—*Observed pressure "p" at the 14 holes at various air speeds and zero pitch and yaw.*

Number of hole.	Air speed in miles per hour.				
	20	30	40	50	60
	Impact pressure p in inches of water.				
1	+0.196	+0.440	+0.789	+1.226	+1.772
2	+ .119	+ .265	+ .472	+ .740	+1.059
3	+ .013	+ .029	+ .056	+ .084	+ .115
4	− .065	− .153	− .271	− .430	− .629
5	.120	.268	.466	.741	1.049
6	.138	.314	.546	.864	1.235
7	.153	.346	.599	.941	1.352
8	.135	.308	.524	.818	1.169
9	.115	.258	.448	.693	.979
10	.081	.180	.303	.473	.669
11	.035	.078	− .124	− .186	− .256
12	− .005	− .004	+ .013	+ .026	+ .043
13	+ .028	+ .068	+ .124	+ .185	+ .256
14	+ .035	+ .076	+ .133	+ .206	+ .285

TABLE III.—*Point pressure in terms of nose pressure, $p/\frac{1}{2}\rho V^2$, at various wind speeds for Navy No. 2 strut—Angle of pitch and yaw zero.*

Number of hole.	Actual values. Wind speed in miles per hour. 20	30	40	50	60	Values computed by V^2 law.
1	+1.000	+0.998	+1.006	+1.000	+1.004	+1.000
2	+ .608	+ .602	+ .602	+ .604	+ .600	+ .602
3	+ .066	+ .066	+ .072	+ .068	+ .066	+ .067
4	− .332	− .348	− .346	− .350	− .356	− .357
5	.612	.608	.594	.604	.594	.602
6	.704	.712	.696	.706	.700	.704
7	.780	.784	.764	.768	.766	.771
8	.688	.698	.668	.668	.662	.674
9	.566	.586	.572	.566	.552	.567
10	.414	.408	.386	.386	.380	.388
11	.178	.176	− .158	− .152	− .146	− .158
12	− .026	− .010	+ .016	+ .022	+ .024	+ .016
13	+ .142	+ .154	+ .158	+ .150	+ .146	+ .148
14	+ .178	+ .172	+ .170	+ .168	+ .162	+ .164

p=point pressure at any hole.
$\frac{1}{2}\rho V^2$=point pressure at nose.

TABLE IV.—*Along-stream forces per foot run of strut No. 2 expressed in pounds and in terms of total measured drag—Zero pitch and yaw.*

Air speed (m. p. h.).	Downstream. Push.	Downstream. Suction.	Downstream. Total, P_1.	Upstream. Push.	Upstream. Suction.	Upstream. Total, P_2.	Pressural drag $R_p=P_1-P_2$.	Frictional drag R_f.	Total drag $R=R_p+R_f$.
				POUNDS PER FOOT RUN.					
20	0.0624	0.0477	0.1101	0.0132	0.0818	0.0940	0.0151	0.0036	0.0187
30	.1405	.1030	.2435	.0294	.1831	.2125	.0310	.0075	.0385
40	.2497	.1769	.4266	.0521	.3254	.3775	.0491	.0155	.0646
50	.3902	.2727	.6629	.0812	.5080	.5892	.0737	.0261	.0998
60	.5619	.3859	.9478	.1164	.7308	.8472	.1006	.0406	.1412
				PER CENT OF TOTAL MEASURED DRAG.					
20	334	255	589	71	437	508	81	19	100
30	365	268	633	76	475	551	82	18	100
40	387	274	661	81	504	585	76	24	100
50	391	273	664	81	509	590	74	26	100
60	398	273	671	82	518	600	71	29	100

DIAGRAM I.

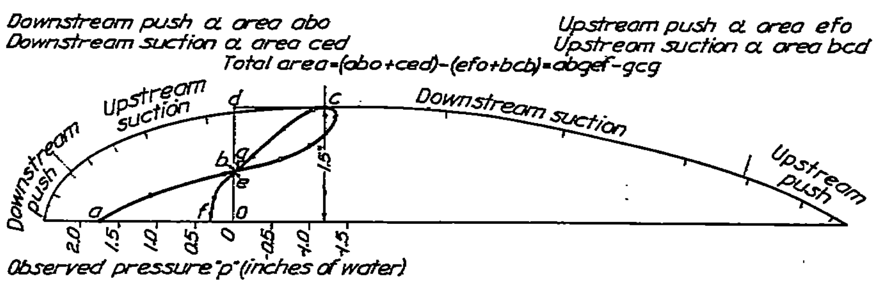


TABLE V.—*Resistance values for Navy No. 2 and No. 3, 5-foot struts with 1/32-inch Gap, at various air speeds and zero pitch and yaw.*

Air speed (m. p. h.).	Measured resistance (pounds).	Resistance due to pressure drop (pounds).	Net total resistance (pounds).	Net drag R per foot of strut at its middle (lbs./ft.).	DV (in.×m.p.h.).	D_1V_1 (ft. ft./sec.).	$K=\frac{R}{DV^2}$ $\frac{lb.}{in.\times(m.p.h.)^2}$	$C=\frac{Rg}{\rho LD_1V_1^2}$
3 BY 10½ INCH NAVY NO. 2 STRUT.								
20	0.0973	0.0038	0.0935	0.0187	60	7.34	0.0000156	0.0366
30	.2004	.0080	.1924	.0385	90	11.00	.0000143	.0335
40	.3363	.0131	.3232	.0646	120	14.67	.0000135	.0317
50	.5186	.0195	.4991	.0998	150	18.34	.0000133	.0307
60	.7327	.0268	.7059	.1412	180	22.00	.0000131	.0307
70	.9776	.0346	.9430	.1886	210	25.67	.0000128	.0302
3 BY 12 INCH NAVY NO. 3 STRUT.								
20	0.0930	0.0043	0.0887	0.0177	60	7.34	0.0000147	0.0347
30	.1795	.0091	.1704	.0341	90	11.00	.0000126	.0297
40	.3010	.0150	.2860	.0572	120	14.67	.0000119	.0280
50	.4612	.0223	.4389	.0878	150	18.34	.0000117	.0275
60	.6604	.0306	.6298	.1260	180	22.00	.0000117	.0274
70	.8952	.0396	.8556	.1711	210	25.67	.0000116	.0273

R=resistance per foot length of strut in pounds.
D=strut thickness in inches.
D_1=strut thickness in feet.
C=Shape coefficient.
V=air speed in miles per hour.
V_1=air speed in feet per second.
ρ/g=0.00237 slug/feet.

TABLE VI.—*Resistance values for Navy No. 2 and No. 3 5-foot struts with 18-inch Gap at various air speeds and zero pitch and yaw.*

Air speed (m. p. h.).	Measured resistance (pounds).	Resistance due to pressure drop (pounds).	Net total resistance (pounds).	Net drag R per foot of strut at its middle (lbs./ft.).	DV (in.×m.p.h.).	D_1V_1 (ft. ft./sec.).	$K=\frac{R}{DV^2}$ $\frac{lb.}{in.\times(m.p.h.)^2}$	$C=\frac{Rg}{\rho LD_1V_1^2}$
3 BY 10½ INCH NAVY NO. 2 STRUT.								
20	0.1069	0.0038	0.1031	0.0206	60	7.34	0.0000172	0.0403
30	.2185	.0080	.2105	.0421	90	11.00	.0000156	.0366
40	.3712	.0131	.3581	.0716	120	14.67	.0000149	.0351
50	.5647	.0195	.5452	.1090	150	18.34	.0000145	.0341
60	.8044	.0268	.7776	.1555	180	22.00	.0000144	.0338
70	1.0831	.0346	1.0485	.2097	210	25.67	.0000143	.0335
3 BY 12 INCH NAVY NO. 3 STRUT.								
20	0.0947	0.0043	0.0904	0.0181	60	7.34	0.0000151	0.0354
30	.1938	.0091	.1847	.0369	90	11.00	.0000137	.0321
35	.2576	.0119	.2457	.0491	105	12.84	....	.0314
40	.3292	.0150	.3142	.0628	120	14.67	.0000131	.0308
45	.4123	.0185	.3938	.0788	135	16.50	....	.0304
50	.5067	.0223	.4844	.0969	150	18.34	.0000129	.0304
55	.6088	.0262	.5826	.1165	165	20.17	....	.0302
60	.7272	.0306	.6866	.1373	180	22.00	.0000127	.0299
65	.8606	.0350	.8256	.1651	195	23.84	....	.0306
70	.9865	.0396	.9469	.1894	210	25.67	.0000129	.0303

R=Resistance per foot length of strut, in pounds.
D=strut thickness in inches.
D_1=strut thickness in feet.
C=Shape coefficient.
V=Air speed in miles per hour.
V_1=Air speed in feet per second.
ρ/g=0.00237 slug/ft.

TABLE VII.—*Effect of gap on shape coefficient at various wind speeds and zero pitch and yaw.*

Gap (inches).	Air speed in miles per hour.					
	20	30	40	50	60	70
	Shape coefficient $=C=Rg/\rho LD_1V_1^2$.					
3 BY 10½ INCH NAVY NO. 2 STRUT.						
.03	0.0366	0.0335	0.0317	0.0307	0.0307	0.0302
.28	.0382	.0345	.0328	.0325	.0319	.0317
.53	.0397	.0349	.0336	.0328	.0325	.0323
1.00	.0401	.0360	.0343	.0334	.0329	.0329
1.50	.0401	.0364	.0346	.0337	.0332	.0331
2.00	.0401	.0365	.0348	.0339	.0335	.0335
3.00	.0401	.0364	.0349	.0344	.0341	.0339
4.00	.0398	.0366	.0351	.0347	.0343	.0340
6.00	.0398	.0366	.0351	.0343	.0339	.0337
9.00	.0398	.0366	.0351	.0343	.0338	.0336
12.00	.0398	.0366	.0351	.0342	.0338	.0336
18.00	.0403	.0366	.0351	.0341	.0338	.0335
3 BY 12 INCH NAVY NO. 3 STRUT.						
.03	0.0347	0.0297	0.0280	0.0275	0.0274	0.0273
.28			.0296	.0296	.0294	.0294
.53	.0363	.0319	.0304	.0301	.0296	.0295
1.00	.0369	.0324	.0309	.0303	.0300	.0298
1.50	.0368	.0335	.0316	.0310	.0309	.0310
2.00	.0372	.0338	.0321	.0316	.0317	.0324
3.00	.0371	.0331	.0314	.0308	.0306	.0308
4.00	.0363	.0324	.0310	.0306	.0303	.0304
6.00	.0342	.0321	.0309	.0308	.0307	.0314
9.00	.0360	.0333	.0314	.0309	.0308	.0307
12.00	.0371	.0331	.0313	.0308	.0308	.0307
18.00	.0354	.0321	.0308	.0304	.0299	.0303